2700° C; TiN: 3200°C). Thus, even if a nitride is formed on the surface of a metal during etching, the nitride will remain on the metal surface as a passive film and never vaporize as a reaction product. Further, the metal nitride such as TiN, TaN, etc. will not effect a chemical reaction (nitration) with nitrogen any more. Namely, it can be said that etching of the above material with an NH_3 plasma is effected only by physical sputtering.--

A7 cn'

REMARKS

The claims are 1-20, with claims 1 and 11 being independent. Reconsideration of these claims is expressly requested.

The specification is objected to because of minor informalities. Applicants have amended the specification to correct the informalities, as well as several typographical errors. No new matter has been added. Withdrawal of the outstanding objection is respectfully requested.

Claims 1-4, 6-15 and 17-20 stand rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over U.S. Patent No. 6,037,255 (Hussein). Claims 5 and 16 stand rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over Hussein in view of EP 0 880 164 (Suzuki). These rejections are respectfully traversed.

The present invention is directed to a method for etching an organic film using a hard mask (intermediate) layer, which contains an insulating film (e.g., SiO_2 film) and a metal film (e.g., Al film). Due to the presence of the metal in the hard mask layer, the etched shape of the dielectric layer is improved.

Hussein is directed to an IC production method in which a photoresist is removed simultaneously when etching a dielectric film and an IC production method through a damascene process using an organic film. Hussein, however, teaches using <u>only</u> an insulating film such as SiO_2, SiN or SiOF as a hard mask for etching an organic film,

while the present invention uses a metal such as Al or Cu, as mentioned above, to attain a high etch selectivity with regard to an organic film to effect highly accurate etching.

The Examiner alleged on page 2 of the Office Action that "Hussein teaches using a hard mask material that comprises titanium (column lines 37- 38 and column 2, lines 43- 49). Hussein et al. also discloses the utility of tantalum in the barrier/mask layers (column 3, line 63)." Applicants respectfully disagree with the Examiner's interpretation of Hussein.

Applicants respectfully submit that a barrier layer in Hussein is not equivalent to the presently claimed hard mask layer. The differences between these layers will be described in detail below with reference to attached Fig. A, which illustrates the semiconductor production steps as described in Hussein.

Hussein refers to a barrier layer on a first conductive layer 101 by reference numeral 102. The barrier layer of the second conductive layer (hereinafter referred to as 201) in the via or trench shown in attached Fig. A6 is not shown in Fig. 1 of Hussein. The Examiner will note that it is evident from the production steps in Hussein that the barrier layers 102, 201 do not function as the hard mask layer 104 and are distinct therefrom.

The Examiner's attention is directed to Fig. 1C in the subject application and attached Fig. A5. These figures show structures after the etching process has been performed. Specifically, in comparing the layers in the structures, the Examiner will note that only hard mask 104 corresponds to the intermediate layer of the present invention, which consists of the metal film 12 and the silicon dioxide film 2. The barrier layer 102, at most, corresponds to stopper film 7. Therefore, clearly, the barrier layers in Hussein cannot be the hard mask layer of the present invention.

The following is a list of materials for the barrier layer 102, 201 and hard mask layer 104 described in Hussein:

barrier layer 102:	silicon nitride, other materials that can inhibit diffusion from conductive layer, titanium nitride or oxynitride, silicon dioxide (col. 2, lines 37- 56; column 4, line 44- 46; column 5, line 47- 57);
barrier layer 201:	refractory material such as titanium nitride or tantalum, insulating material such as silicon nitride (col. 3, line 60 - col. 4, line 8);
<u>hard mask layer 104</u>:	<u>silicon nitride, silicon dioxide and SiOF</u> (col. 3, lines 37- 47; col. 4, line 66 - col. 5, line 2).

It is clear that while Hussein teaches using conventional materials such as TiN, TaN, etc, for the barrier layer, it does not disclose or suggest using these or any other metal or a metal-containing materials for the hard mask layer. Thus, Hussein cannot render obvious the presently claimed invention.

As discussed above, a key feature of the present invention is in forming a hard mask layer a metal or a metal-containing material, which leads to improving the etched shape of the dielectric layer. Further, since in the present invention the metal portion of the hard mask layer is removed in the CMP step corresponding to attached Fig. A8, a short circuit of a wire, even when a conductive material is used, does not occur.

Suzuki is directed to a plasma processing apparatus. This reference was cited for a teaching of a surface-wave interfered plasma. Even if assumed, arguendo, that Suzuki contains the alleged teaching, this reference, like Hussein, does not disclose or suggest an intermediate layer comprising a metal or metal compound. Therefore, Suzuki,

alone or in combination with Hussein, cannot affect the patentability of the presently claimed invention.

Wherefore, Applicants respectfully request that the outstanding objection and rejections be withdrawn and the subject application be passed to issue.

Applicants' undersigned attorney may be reached in our New York office by telephone at (212) 218-2100. All correspondence should continue to be directed to our address given below.

Respectfully submitted,

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APPENDIX

Application No. 09/832,978
Attorney Docket No. 03500.015293

IN THE SPECIFICATION:

The paragraph beginning on page 3, line 1, and ending on page 3, line 10, has been amended as follows:

As described above, in etching of an organic low-dielectric-constant film, the main components of the photoresist mask 1 and the organic low-dielectric-constant film 3 [2] are both organic substance and it is difficult to secure the selectivity enough to maintain the etching shape, so that the so-called hard mask method is generally used in which a photoresist pattern is transferred once to an inorganic film 2 such as SiO_2 film and an organic low-dielectric-constant film 3 is etched with the inorganic film 2 employed as the mask.

The paragraph beginning on page 7, line 1, and ending on page 7, line 11, has been amended as follows:

As the metal film 12, a pure metal comprising at least one selected from aluminum [aluminium] (Al), copper (Cu), titanium (Ti), cobalt (Co), tantalum (Ta), platinum (Pt), tungsten (W), chromium (Cr), etc. or an alloy thereof may be used. Alternatively, a silicate or nitride of the metal selected from them may also be used. Specifically, tantalum nitride (TaN), titanium nitride (TiN), tungsten nitride (WN), titanium silicon nitride (TiSiN), tantalum silicon nitride (TaSiN), tungsten silicon nitride (WSiN), or the like is referred.

The paragraph beginning on page 8, line 8, and ending on page 8, line 13, has been amended as follows:

[As the gas for etching the organic insulating film 3 used in the present invention, an] <u>An</u> oxygen-containing gas, a hydrogen-containing gas, or the like <u>can be used as a gas for etching the organic insulating film 3</u> [is referred], but for the reason mentioned below, a nitrogen- or hydrogen-containing gas is <u>preferred</u> [preferably used].

The paragraph beginning on page 8, line 25, and ending on page 9, line 6, has been amended as follows:

As the conductor 8, a pure metal comprising at least one selected from tungsten, copper and <u>aluminum</u> [aluminium] formed by a method such as CVD, sputtering, plating or others or an alloy thereof may preferably be used, and at the interfaces of the conductor 8 with the respective layers 12, 2, 3, 7 and 4, at least one layer of a material selected from TiN, TaN, WN, Ti, Ta, TiSiN, TaSiN, etc. serving as a barrier metal may be interposed.

The paragraph beginning on page 10, line 17, and ending on page 11, line 7, has been amended as follows:

Figs. 2A to 2C show Vpp independence of the etch rates of an organic low-dielectric-constant film and an SiO_2 film in an NH_3 plasma in the case of using a surface -wave interfered plasma system (hereinafter, referred to as SIP). As an SIP, the system disclosed in Japanese Patent Application Laid-Open No. 11-40397, U.S. <u>Patent No. 6,497,783 B1</u> [patent application Ser. No. 082,006 filed on May 20, 1998] or the like may be used. The term "Vpp" as used herein means a peak-to-peak voltage of a high frequency bias applied to a substrate. When a

high frequency bias of not higher than 2 MHZ frequency is applied to the substrate, electrons are accelerated during a half period at the positive side and ions are accelerated during a half period at the negative side. In other words, Vpp/2 means a maximum value of the voltage for accelerating ions or electrons in a plasma. For example, a case where Vpp/2 is 600 V means that ions are incident on the substrate with a maximum energy of 600 eV.

The paragraph beginning on page 12, line 11, and ending on page 12, line 17, has been amended as follows:

As described above, since deterioration in film quality due to the adsorption of oxygen to an organic low-dielectric-constant insulating film is inevitable in the case of using a plasma of an <u>oxygen-containing</u> [oxygenic] gas, abnormal film formation might occur because of the desorption of oxygen during the subsequent film forming process for a conductor such as a tungsten plug.

The paragraph beginning on page 14, line 8, and ending on page 15, line 2, has been amended as follows:

Consideration based on the results of the above experiments leads to the conclusion that the material most suitable for a hard mask (intermediate layer) in the etching of an organic low-dielectric-constant film using NH_3 gas is a material which is unreactive to an NH_3 plasma and highly suitable to the existing semiconductor production processes. The materials satisfying the above conditions include wiring metals such as Al, Cu, Ti, Co, Ta, Pt, Cr, W, etc. and metal nitrides for the barrier metal such as TiN, WN, TaN, etc. Generally, metal nitrides are high melting point compounds having melting points of 2000°C or more and are stable at very

high temperatures (for example, AlN: 2700° C; TiN: 3200° C). Thus, even if a nitride is formed on the surface of a metal during etching, the nitride will remain on the metal surface as a passive film and never vaporize as a reaction product. Further, the metal nitride such as TiN, TaN, etc. will not effect a chemical reaction (nitration [nitridation]) with nitrogen any more. Namely, it can be said that etching of the above material with an NH_3 plasma is effected only by physical sputtering.

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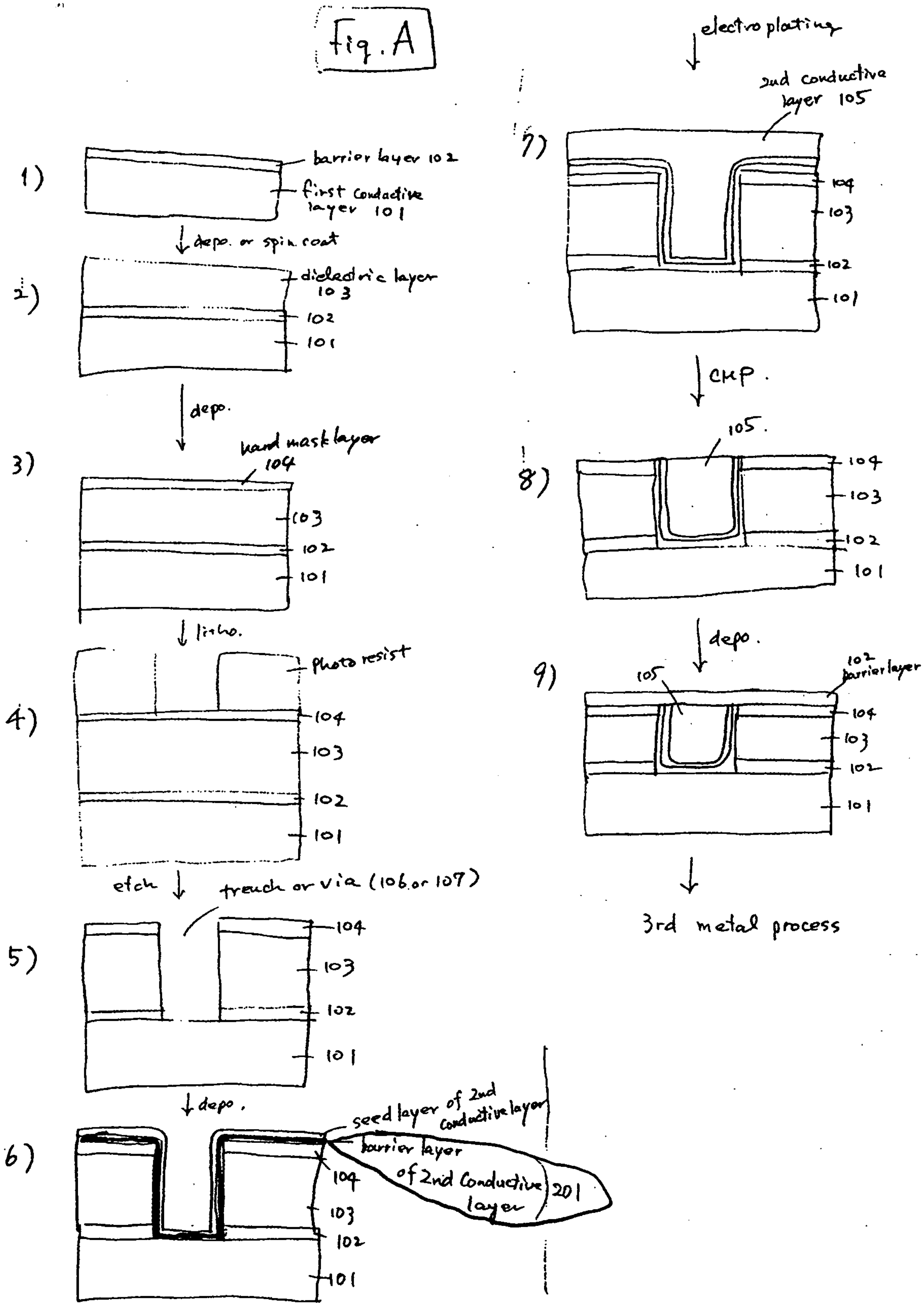
fig. A


1)
barrier layer 102
first conductive layer 101
depo. or spin coat
2)
dielectric layer 103
102
101
depo.
3)
hard mask layer 104
103
102
101
litho.
4)
photo resist
104
103
102
101
etch
trench or via (106 or 107)
5)
104
103
102
101
depo.
6)
seed layer of 2nd conductive layer
barrier layer of 2nd Conductive layer 201
104
103
102
101
electro plating
2nd conductive layer 105
7)
104
103
102
101
CMP.
105.
8)
104
103
102
101
depo.
105
102 barrier layer
9)
104
103
102
101
3rd metal process